

Deformation and Velocity Measurements at Elevated Temperature in Fractured Blocks of Tuff.

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This abstract presents preliminary results of laboratory testing of 0.5m scale block samples of Topopah Spring Tuff conducted in support of the Yucca Mountain Site Characterization Project. The overall objective of these tests is to investigate the thermal-mechanical, thermal-hydrological, and thermal-chemical response of the rock to conditions similar to the near-field environment (NFE) of a potential nuclear waste repository. We present preliminary results of deformation and elastic wave velocity measurements on a block of Topopah Spring tuff tested in uniaxial compression to 8.5 MPa, and at temperatures to 85 °C. The sample assembly for room temperature testing of the block is shown in Figure 1.

Data at this scale are needed to provide input to models used for analysis of a potential repository, as data from smaller samples commonly tested in the laboratory do not provide information on fracture behavior, and very few data sets are available from in situ rock masses. Moreover, tests at this scale have the benefit that known boundary and environmental conditions can be imposed on a rock sample that contains multiple fractures, while data from field scale tests are often poorly constrained due to inherent limitations on boundary conditions, sampling intervals and material characterization. Finally, data from these tests will be used to support the Large Block Test currently planned to be conducted on a 3m x 3m x 4.5m block of fractured tuff excavated at Fran Ridge near Yucca Mountain.

Our results show that most deformation occurred in vuggy zones and along fractures. The matrix material is an order of magnitude stiffer than the fractured rock, which in turn is an order of magnitude stiffer than an individual fracture. Increasing the vertical stress caused horizontal fractures to close, increasing rock stiffness measured in the vertical direction. Cyclic loading at low stress may cause subcritical crack growth. Raising stress to 8.5 MPa and cycling the load caused cracks to grow, opened the vertical cracks, and reduced the deformation modulus and the compressional wave velocities measured in the horizontal direction. Cohesion of fractures is observed during unloading. Observed values for fracture cohesion are about an order of magnitude lower than values usually assumed for modeling. Increasing the temperature caused cracks to close, and the closure of vertical cracks led to increased compressional wave velocities measured in the horizontal direction.

Results at elevated temperature indicate that some deformation occurred at constant stress while the sample was heated to temperature and held at temperature, and that the deformation modulus decreases as temperature is increased. We also found a weak but consistent correlation between the velocities and the temperatures, and postulate that high temperatures help to close and heal cracks and thus are related to high velocities.

These results provide constraints on how the flow and transport properties of the rock in the very near-field region of a repository may change as the temperature and stress fields change over time.

Work performed under the auspices of the U.S. Department of Energy by This work was supported by the Yucca Mountain Site Characterization Project. Lawrence Livermore National Laboratory under contract W-7405-ENG-48.



Figure 1. Photograph of 0.5m scale block assembled into test apparatus